

**Tanzania**

**Coastal**

**Management**

**Partnership**

**SUMMARY OF COASTAL ECOSYSTEM PROFILES  
FOR TANZANIA**

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**Tanzania Coastal Management Partnership and the  
Science and Technical Working Group (STWG)  
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**A joint initiative between the National Environmental Management Council, the  
University of Rhode Island/Coastal Resources Center and the United States Agency for  
International Development.**

## PREFACE

The Tanzania Coastal Management Partnership (TCMP) established Science and Technical Working Group (STWG) in July 1999. TCMP is a joint initiative between the Government of Tanzania, the National Environmental Management Council, the United States Agency for International Development (USAID) and the Coastal Resources Center (CRC) of the University of Rhode Island (URI). The main goal of TCMP is to establish the foundation for effective coastal management in Tanzania. TCMP is committed to working with the existing network of Integrated Coastal Management (ICM) programme and practitioners to facilitate a participatory transparent process to unite the Government and the community, science and management, sectoral and public interests with a primary goal of conservation and development of coastal ecosystems and resource. STWG is intended to provide the primary bridge between coastal managers and the science community studying coastal marine issues at the local and national level. More specifically, STWG provides a clearinghouse mechanism for the integration of science and better coastal management. The Institute of Marine Sciences (IMS) of the University of Dar es Salaam provides the Secretariat to the STWG and the IMS Director is the Chairperson of the Group.

This document contains the summary of coastal ecosystem profiles for Tanzania based on synthesis reports that were prepared in six thematic areas: shoreline erosion, water quality and pollution, marine fisheries, coral reefs, mangroves and other marine living resources. These were selected as natural science topics with relevance for coastal management in a Workshop on Science for Coastal Management held at the Institute of Marine Sciences, Zanzibar in July 1998. The summaries were prepared as a follow-up to that Workshop with the goal of carefully reviewing scientific knowledge in science areas important for management. They are part of a larger effort that pulled together an exhaustive list of science references on the six topics and synthesized the state of existing knowledge in Tanzania.

This summary is a valuable source of information for marine resource managers and policy makers in Tanzania. It is also a useful document for graduate students and marine scientists. As a complement to this document, the detailed synthesis reports on the six themes, full list of references and selected annotated bibliography are also available at TCMP and the library of the Institute of Marine Sciences (IMS), Zanzibar.

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## 1.0 Shoreline Erosion

### 1.1 Why protect the shoreline

Shoreline erosion is a major threat to expensive properties located along the coast (residential houses, tourist hotels, industrial installations etc.). It also results in the loss of prime land for agriculture, salt pans, hotel development, and general recreational areas. In some extreme cases shoreline erosion can lead to complete disappearance of Islands, as has been the case in 1987 for Maziwi Island in Tanzania. Sediment transport by waves and currents can often lead to harbour siltation problems. Coastal erosion can therefore have potentially serious negative effects on the tourism industry and national economy in general. More importantly, coastal erosion can have significant affect on the lives of coastal communities who depend on the coastline for their livelihood.

Shoreline protection has significant social, economic and ecological importance for coastal communities who depend on the coastline for their income, employment and subsistence. The coastline must be protected if the tourism business and industrial infrastructure need to be sustained in Tanzania.

The total length of the coastline in Tanzania mainland is about 800 km, extending from the border with Kenya in the north to Ruvuma River in the south. Communities living along many coastal areas in Tanzania are often faced with the difficult problem of coastal erosion. Beach or shoreline erosion is a condition where the shoreline position changes with time and space. The resulting loss of land and property has immense consequences on the society in Tanzania coastal areas. This is one of the major issues for coastal managers when it comes to protection and conservation of coastal resources.

Given the potential socio-economic impacts of coastal erosion, stakeholders normally adopt defensive measures that seek to maintain shorelines in their present position. This is achieved either by building protective structures or strengthening the coast through beach nourishment. However, in the absence of information on specific causes of erosion, design principles of protective structures and the consequences associated with these measures, the result are often costly and unexpected. It is very important to realise that, prior to any design of structures or any erosion control measures, geological and hydrodynamic conditions of the affected area must be thoroughly investigated.

### 1.2 Status and trends of shoreline erosion in Tanzania

Available records indicate that the coastline of Tanzania has been eroding at various rates in different areas. The affected areas in mainland Tanzania extend from Pangani in the north through Dar es Salaam to Mtwara in the south. For example, significant erosion over the last few decades has resulted in the loss of several buildings at Africana beach hotel and homes at Kunduchi beach area in Dar es Salaam. Some of the affected areas in Zanzibar include Maruhubi, Nungwi, Paje and Jambian areas.

The scientific data indicate significant shoreline erosion over the last few decades in Tanzania. The typical shoreline erosion rate at Kunduchi area is up to 4m per year. This rate of erosion is quite significant and alarming. Another example is the complete disappearance of Maziwi Island in 1987 as a result of severe erosion.

It is known that the erosion rate and character in Tanzania coastlines varies from place to place and from season to season, depending on the local coastal configuration, sedimentary characteristics and hydrodynamic conditions. However, there have been very few scientific studies conducted to evaluate the extent of the problem and possible suggestions for control measures.

### **1.3 Basic causes of shoreline erosion**

Since shoreline advances can be short- or long-term, it is important to understand the nature of the cause before attempting any protective measures. Erosion is generally a result of several causes, which can act independently or in association. These causes can be divided into two major categories; natural and human related causes. Natural causes can be due to physical conditions or the forces of nature. The physical conditions depend on the geology, geomorphology and topographic conditions of a given area. On the other hand the natural forces mainly depend on the changes in climate, hydrology and coastal processes.

The main human related causes of shoreline erosion in Tanzania includes; loss of natural shoreline protection by clearance of vegetation and coral mining, loss of natural nourishment of beach sand by mining of sand on riverbeds, and construction of jetties and harbors causing a change in local sediment dynamics.

The potential impacts of climate change by itself may not always be the largest threat for the stability of coastlines. However, when this occurs in conjunction with other factors, such as man's actions, they can become a serious problem for coastal communities. Factors that can adversely affect the natural capability of coastal areas to adapt to climate change include non-sustainable resource use and coastal development. These factors include over-exploitation of resources (such as sand and coral mining, mangrove cutting, groundwater depletion), sediment starvation and urbanisation (such as dam construction, human settlement and construction along beaches).

### **1.4 The state of existing scientific knowledge on shoreline erosion in Tanzania**

Studies related to coastal erosion are expected to provide information on the status and causes of erosion. Once the status and causes are known, scientists, engineers and managers can take appropriate measure for the control and sustainable management of the coastal zone. These studies can be classified in the following categories. (1) Coastal geology and geomorphological

characteristics. (2) Hydrology; for example river water discharge, sediment transport and nearshore/estuarine/delta hydrodynamics). (3) Climate change; for example wind patterns, rainfall and sea level change. (4) Hydrography; for example bathymetry, ocean circulation and temperature-salinity characteristics. (5) Coastal processes; for example nearshore waves and currents. (6) Resource utilisation; for example non-sustainable developments and resource use.

Many of the studies that have been conducted on coastal erosion in Tanzania provide baseline information. Only a few of the studies conducted have been experimental, review or modelling studies. Most of the recent studies have been carried out by qualified scientists. Even in cases where students conducted the research, adequate supervision has occurred by capable scientists and most of the works led to postgraduate degrees. A good number of baseline studies have been conducted on the geology and geomorphology of coastal areas. Most of these studies were focussed on the origin and manner in which the beach areas were preserved, geomorphological development, general geology, tectonic setting, grain-size distribution and sediment transport.

Very few studies have been conducted in the areas of coastal hydrography. The earliest work on the hydrography of water off the Tanzanian coast was conducted in the 1950's. Two more works were conducted in the 1970's. Since that time there have been no publications in this area. There have also been very few studies on hydrodynamics and bathymetry of nearshore waters. The few studies that are available on nearshore oceanography were conducted in the 1990's, mostly by the Institute of Marine Sciences, Zanzibar. A particular lack of research is also seen in the areas of climate change, coastal processes and resource utilisation. Many of the available literature in these areas appear to have been conducted in recent years. Another area that has received rather small effort is research on hydrology. Much of the work was conducted between 1960-1970 where many surveys were conducted in search of suitable sites for hydropower stations on major rivers and deltas.

In summary, the following information gaps have been identified based on a comprehensive review of the existing literature on coastal erosion in Tanzania. The information on coastal geology and geomorphology seems to have been well covered for Dar es Salaam and north-eastern Tanzania. Hydrology is well covered only for Rufiji but the information is rather old. The winds seem to have been analysed only for extreme speeds. Statistical analysis of wind directions is not covered. Rainfall, atmospheric pressure and sea level trends are not well covered. The information on general hydrographic conditions is available, however research in nearshore bathymetry and hydrodynamics require more work. The studies on nearshore waves and currents are localised and are lacking enough temporal variations to warrant statistical analysis. Similarly, sediment transport studies along the entire coastline, river deltas and estuaries require more work.

## **1.5 Research recommendations to address gaps in scientific information**

There is a need to establish a strong research program in nearshore oceanography with a specific focus of investigating the relationship between the shoreline and bathymetric changes to the prevailing hydrodynamic and climatic conditions. Emphasis should be placed on process-oriented studies and development of physical models that explains the ongoing processes and trends in shoreline dynamics. Further studies are required to determine sediment transport paths in both littoral and shelf areas. Sediment transport studies and other recommendations based on scientific data need to be fully considered in all development projects on rivers and shoreline areas.

**Practical recommendations for filling coastal erosion science gaps in a realistic time period:**

- Establish strong research program in nearshore oceanography
- Conduct studies on sediment dynamics in littoral and shelf areas
- Initiate numerical modelling studies in the nearshore zone.
- Expand geographic coverage
- Create a national body to revive sea level monitoring
- Establish experimental studies to address coastal erosion problems

There is also a need to establish gauging stations near the outlets of all major rivers for monitoring both water discharge and sediment flux. Whenever numerical models are used as tools of analysis for solving the problems related to coastal erosion, effort should be made to include field data for comparison purposes and model validation. In terms of the coastal geology, geomorphology and hydrology, there is a need to expand the geographic coverage of field studies. More systematic work is still needed in geological, sedimentological and radiometric dating in order to establishing conditions of sea-level change along the coastline of Tanzania.

Sea level monitoring in Tanzania has been inadequate and unreliable. There are only two operational stations: one in Dar es Salaam and the other in Zanzibar. The small spatial and temporal scales of the collected data reduce the reliability of its application at larger scales. There is therefore a need to create a national body to revive and oversee the sea-level measurements in Tanzania. There is a complete lack of experimental studies in the nearshore zone that are specifically designed to address the coastal erosion problem. There is also a need to study the climate change over the past few decades and relate the results to the erosion trends along the Tanzania coastline.

## **1.6 Likely management solutions emerging from the scientific literature**

Poor existing policies such as those that encourage investment in potentially hazardous coastal areas, as well as ineffective management practices such as inappropriate coastal defence schemes and coastal habitat conversions are some issues that create pressure on the coastlines. It is therefore important to formulate enforceable policies that are specifically targeted to control shoreline erosion likely to be caused by human related factors.

Install low-cost and low-tech control measures for areas affected by beach erosion. Only detailed engineering designs based on scientific data should be used for protecting properties in the erosion prone areas. The present experience in Tanzania has shown that groynes have not solved erosion problems. The government should promote awareness on the effects of different protection methods on shoreline erosion.

The destruction of natural shoreline protection capability through coastal development, cutting of mangroves and sand mining on riverbeds are some of the factors that can accelerate the problem of coastal erosion. It is therefore important to promote education among local coastal communities on the impact of shoreline erosion and the problems associated with coastal developments along shoreline areas. There should also be awareness campaigns at all levels on



how the coastal ecosystem is functioning, its values and the threats associated with its degradation.

**Recommended coastal erosion management solutions:**

- Establishment of coastal defence schemes
- Install low-cost and low-tech beach erosion control measures
- Promote awareness on effects of different protective methods and the impact of shoreline erosion
- Carefully controlled development plans in coastal areas
- Establish the 200-m buffer between the shoreline and allowable development areas.
- Formulate enforceable policies targeted on controlling shoreline erosion
- Enforcement of existing laws

Re-establish the 200-metre buffer zone between the coastline and areas allowable for development activities. The government should develop a formal strategy to address issues related to zonation of areas suitable for various activities. The current practice of permitting exceptions to existing regulations should also be discouraged.

## **2.0 Water Quality and Pollution**

### **2.1 Why care about water quality in Tanzania coastal waters**

There are many reasons why we should care about the water quality in Tanzania coastal waters. The most important reason is related to the health of the people who makes use of these waters everyday. This may be either through contact from swimming and other recreational activities or through eating of fish and other edible resources. Some of the pollutants can cause seriously health hazards. On the other hand, the coastal areas encompass a number of habitats that include coral reefs, mangroves, seagrass beds, sandbanks, and beaches. These coastal habitats support various resources, both living and non-living. The wellbeing of these ecosystems depends, to a large extent, on good water quality. For example, pollutants like oil spills can have a serious effect on mangroves, seagrass beds, marine birds and the suitability of beaches for general recreational purposes. This can in turn have an adverse effect on the tourism industry.

The quality of water in coastal waters is extremely important for tourism industry. If the quality of coastal waters is poor, the tourists simply won't be interested with Tanzania beaches. The quality of water is also important for food security and the general health of all coastal ecosystems. Water quality is therefore intricately related to the wellbeing of many communities in Tanzania coastal areas.

## 2.2 Status and trends in water quality and pollution problems in Tanzania coastal waters

Reports indicate that coastal waters fronting such cities and towns as Dar es Salaam, Tanga, Zanzibar and Mtwara are polluted. Other coastal towns could be significantly affected by the problem of domestic pollution as well. Furthermore, land-based activities such as agriculture, industry, and mineral exploitation have further contributed to the degradation of coastal water quality. The expanding coastal populations are also exerting an ever-increasing pressure on coastal waters thus negatively affecting water quality. As a result coastal pollution is increasingly becoming a major problem in Tanzania coastal towns.

The water quality in Tanzania coastal waters is in fairly good condition, except at waters fronting major towns, where the waters are polluted from mainly untreated domestic sewage. The current population increase in coastal town is expected to increase pollution problems in coastal waters.

Currently, over 10 million people live in the coastal areas of Tanzania. This figure can significantly increase in the next few years. These trends are therefore very worrisome. Although the water quality in most coastal areas of Tanzania is in fairly good condition, except at waters fronting major towns. The situation can change very quickly with the increased urbanisation of many coastal areas and based on the projected industrial and agricultural development.

## 2.3 Sources of water quality and pollution problems in Tanzania coastal waters

The coastal waters in many parts of Tanzania are in pristine condition. The exception is in coastal areas bordering major towns and cities that are recipient of untreated municipal and industrial wastes, and those receiving agricultural wastes. These include the main coastal towns of Dar es Salaam, Tanga, Mtwara and Zanzibar. In Zanzibar, faecal coliform and total coliform levels of up to 70-100 per ml and numerous thousands per ml of seawater respectively have been reported in the waters fronting the Zanzibar Municipality. Nutrient levels are also higher than normal for tropical seawaters indicating anthropogenic inputs.

The main sources of water quality problems in the coastal waters of Tanzania includes: Domestic and industrial waste especially in Dar es Salaam, Zanzibar and Tanga, Agro-chemicals particularly in Tanga and Sedimentation problems at the entrances of large rivers like Rufiji, Ruvu and Pangani.

Likewise, it has been reported that there is a proliferation of macroalgae in Tanga coastal waters due to excess nutrient loading from discharges from a fertiliser factory and from the municipality. Coastal pollution in Tanga is also caused by discharge of effluents from sisal decorticating plants in the area. Up to twenty plants discharge their wastes into the coastal waters via the Pangani, Sigi, Mruazi/Mnyuzi and Mkurumzi Rivers.

In Dar es Salaam, domestic waste is one of the leading source of pollution. The waste generated by 15% of the city residents who are connected to the sewer system is discharged into the sea untreated. As a result, the coastal waters off the city, especially the harbour area, are heavily polluted. Discharging untreated sewage in Dar es Salaam harbour has resulted in high faecal and total coliform levels. The situation is made worse by broken sewer pipes which discharge untreated sewage on sandy-mud flats near the harbour. This is now threatening invertebrates and fish in those areas. It has also been reported that alarming levels of chlorinated organic compounds have been measured in the harbour areas. Commonly identified heavy metals found in Dar es Salaam harbour include Lead, Zinc and Copper. The harbour area also suffers from oil pollution from the refinery at Kigamboni, and industrial wastes from Keko, Chang'ombe, Kurasini, Mtoni and Temeke. These industries discharge heavy metals, pesticides, organic contaminants, and paint wastes into the nearby area.

Msimbazi River and Creek are among the leading water bodies for pollution in Dar es Salaam. The river and creek receives large quantities of untreated domestic wastes from the city's residents in addition to industrial wastes from various industries. The river and creek receive such pollutants as dyes and paint wastes and strong alkalis, oils and organic wastes. Other industrial and agricultural chemicals that pollute the river and creek include heavy metals, PCBs, cyanides, pesticides, and detergents.

Other coastal areas of Tanzania outside major cities and townships though free from domestic wastes do suffer from input of agricultural wastes, including pesticides and fertilisers, via rivers and streams. Most major rivers in the country drain agricultural lands and deposit their waste loads into the coastal waters. Unfortunately, this area of concern has not received sufficient attention in the literature. River discharges on coastal areas also carry with them industrial wastes. For example Kilombero River, which transport wastes from the Mufindi Pulp and Paper Mill from the hinterland to the coast.

The coastal waters of Tanzania are also subjected to the input of heavy loads of sediment especially in areas where major rivers enter the sea. Even though such inputs can be a result of natural events such as storm events and heavy rains in upland areas, poor agricultural practices have been known to play a leading role in water quality degradation due to sedimentation. A direct consequence of this is the smothering of corals and other organisms, as well the reduction of aesthetic value of the water thus making it less attractive for such activities as tourism and general recreational activities.

## **2.4 The state of existing scientific knowledge on water quality**

Most of the studies on water quality and pollution have been carried out either within or next to major towns and cities (Dar es Salaam, Tanga, and Zanzibar). One study was carried out in Mtwara. The existing studies are therefore clearly concentrated on pollution emanating from sewage. Consequently, very few studies have looked at other sources of pollution, for example heavy metal, organic and agrochemical based pollution. The geographical coverage can therefore be classified as low. Most of these studies were conducted by qualified researchers, consultants and students (under supervision). The state of existing knowledge is therefore considered as being of high quality.

## 2.5 Research recommendations to address gaps in scientific information on water quality

Most water quality and pollution studies have been conducted on waters off major cities and towns only, where domestic sewage has been the focus of investigation. There is therefore a need to conduct similar studies in other coastal areas of Tanzania, especially in areas where major rivers enter the oceanic waters and areas with major agricultural activities. There is also a need to conduct more studies on pollution from heavy metals and that emanating from organic compounds and agro-chemicals.

**Practical recommendations to fill the water quality and pollution science gaps in a realistic period of time:**

- Increase the geographic coverage of the studies
- Expand the scope of research on pollution due to heavy metals, agro-chemicals and other industrial pollutants.
- Initiate studies on the relationships between pollutants and physical forces such as dispersion and ocean mixing.
- Generate baseline information on industrial pollution as well as monitoring of trends on the impact of these wastes on water quality.

Since few industries in Tanzania treat their wastes before being discharged, it is obvious that these untreated wastes are the principal sources of industrial pollution in Tanzanian coastal waters. Given the current pace of industrial development in the country and the fact that only few studies on industrial pollution have been done. There is a need for more studies to be carried out to generate baseline information as well as to follow trends on the impact of these wastes on water quality in coastal areas.

There is a need to increase the breadth of subject coverage in the scientific investigations. For example there is paucity in the information related to the linkage between pollutants and physical forces such dispersion and mixing. Such studies, especially in the area of ocean numerical models can be very useful when it comes to clean up of pollutants like oil spillage. There is also a need to initiate long-term monitoring studies especially in pollution hot spot areas. This is to ensure the safety of the coastal waters at all times and gathering of information that can be constantly used for routine management purposes.

## 2.6 Likely water quality management solutions emerging from the scientific literature

There is a need for the treatment of municipal waste before it is discharged into the sea. Primary waste treatment facilities should be constructed to facilitate initial waste treatment before discharge. An education/outreach program should be designed to promote local awareness of the dangers of pollution and the health risks associated with the problem. There should be formulated guidelines on the design and construction of wells and pit latrines with the view of reducing pollution in the concerned areas. People should be discouraged from using shallow hand-dug

wells and a monitoring program to study the fluctuation of ground water levels and quality should be initiated.

**Recommended water quality and pollution management solutions:**

- Establish low cost treatment of municipal waste
- Reduce the amount of domestic waste
- Develop an educational/outreach program for public awareness
- Formulated guidelines on the design and construction of wells and pit latrines
- Repair broken sewage pipes
- Promote the use of composting toilets

The leaks in sewage disposal pipes should be repaired to eliminate the health risks associated with high faecal coliform concentrations. The public should be made aware of the health risks associated with eating fish and shellfish from contaminated sites as well as the risks associated with swimming in sewage contaminated waters. The sewerage systems should be rehabilitated and the construction of discharge pipes should take into consideration the local current patterns in the nearshore areas to make sure that sewage is flushed out to the open ocean. Composting toilets should be promoted in order to reduce the volume of sewage discharged into the sea.

### **3.0 Marine Fisheries**

#### **3.1 Importance of marine fishery in Tanzania**

The inshore marine fishery is extremely important to coastal communities in Tanzania. The number of full-time fishermen in Zanzibar is 23,000 and there are about 15,000 fishermen along the mainland coast of Tanzania. The importance and impact of the fishery extends much beyond the full-time fishermen, and includes all those involved in boat construction and repair, and marketing and sale of fish products. Almost all people in coastal communities are involved in fishing activities in one form or another and fish products contribute over 70 percent of the protein intake of coastal populations.

The marine fishery in Tanzania is located along a relatively narrow strip along the coast where sea and land meet. About 95 percent of the fishery is artisanal, based on the use of traditional boats and gear. The artisanal fishery is more or less delineated by the continental shelf, which is about 4 kilometres offshore with the exception of the Zanzibar and Mafia channels where the shelf extends for some 60 kilometres.

Marine fishery is very important to many Tanzania coastal communities for their income, employment, food security, and subsistence. Tanzania exports about US \$ 1.3 million in marine fishery product annually. It is also important for the health of coastal ecosystems and provides support for the tourism industry.

Tanzania exports about US\$1.3 million in marine fishery products from the mainland and Zanzibar. The main export products are shrimp, sea cucumber, shells, lobster, crab, squid, octopus, sardines, fish offal and aquarium fish. Most of the export revenue comes from the harvest of shrimp. The two main fishing grounds for shrimp are around Bagamoyo/Sadani and the Rufiji Delta. The Tanzania Fisheries Corporation based in Dar es Salaam and the African Fishing Company based in Zanzibar are the main industrial fishing companies.

The high seas, or the “Exclusive Economic Zone” that extend over 300 kilometres out to sea, are so far unexploited by Tanzanian fishermen and the resource potential is not known. High value migratory fish species such as tuna, sailfish and marlin are found in this area.

### **3.2 Status and trends in the condition of fishery**

The inshore fishery is showing signs of overexploitation. This can be seen especially in Zanzibar where statistics document a declining trend in annual catch. The total annual catch in Zanzibar was about 20,000 tons in 1988, but it has now dropped to less than 13,000 tons per year. The declining trend is confirmed by detailed long-term studies in some localised areas such as Chwaka Bay, Zanzibar and in specific reef fisheries of Zanzibar. Interviews everywhere with elder fishermen also confirm that in the past they used to catch much more and bigger fish in near shore waters in comparison to today.

During the period between 1984 and 1995, the annual fish catch ranged between 45,000 and 54,000 tonnes for the mainland. Also during this period, the number of fishermen increased each year. Until 1990, increased effort resulted in increased catches; however, during the last decade, catches have been in decline, perhaps signalling the fishery is over-exploiting stocks.

Some fisheries have declined more than others, such as the Zanzibar fishery of small pelagics (the purse seine fishery) and the shark fishery. The catch of small pelagics by the boats of the Zanzibar Fisheries Corporation declined from 600 tons in 1986 to 91 tons in 1997. Shark fin trade has also declined and some species are now rarely seen in Tanzania waters.

The status of inshore marine fishery is classified as poor, due to harvest beyond sustainable yield. This is supported by scientific data where there has been significant decline in catches over the last decade in all fisheries. The status of offshore fishery is largely unknown, due to lack of research vessel to carry out stock assessment in Tanzania open waters.

These trends are worrisome, especially considering that the critical habitat for inshore fisheries, such as coral reefs and mangroves, are being degraded at a rapid rate in many areas. In the marine ecosystem everything is interconnected. The loss of mangroves, for example, reduces vital nursery grounds for fish and crustaceans, and it may cause erosion and sedimentation, degrading coral reefs, essential for inshore fish diversity and health.

### **3.3 Sources of pressure on fisheries resource in Tanzania**

The demand for fishery resources has been gradually increasing with the increase in population and tourism development. This has caused an increase in fishing pressure and the use of gear and

techniques that are destructive and cause damage to reefs. Most of the destructive methods are prohibited by law but continue to be used due to lack of surveillance, enforcement and public awareness. The common destructive methods are dynamite fishing, dragged nets (juya la kigumi), and the use of spears and sticks, beach seine and poison.

The use of dragged nets is one of the most difficult to control because the net used is not illegal, however, it is the action involved in the technique of using the net which is a problem--fishermen break coral reefs with sticks to chase away hiding fish.

The main source of pressure on marine fisheries resource in Tanzania includes; destructive fishing practices, coastal population growth and increased demand for fishery products, ecosystem degradation (loss of mangrove and coral reef habitats), land based pollution and localized fishing, especially in coral reef areas.

The use of poison leads to indiscriminate destruction of fish breeding and nursery grounds and has seriously affected populations where the practice is used by destroying larvae and juveniles. Mangrove cutting and loss of mangrove habitat has a similar impact on fisheries. Mangroves are an irreplaceable part of the fish life cycle, providing nursery and breeding grounds for many ecologically and economically valuable fish species. The role of mangroves as nursery and breeding grounds of fish has been studied in some areas.

### **3.4 The state of existing scientific knowledge in marine fisheries**

Much work was conducted on fisheries in Tanzania beginning in the 1950's through the East African Marine Fisheries Organisation. At that time, a research vessel was available and the status of fish populations and composition was well documented, especially in the Zanzibar channel. Today, most fisheries research is conducted by the Tanzania Fisheries Research Institute (TAFIRI) and the University of Dar es Salaam through its Zoology and Botany Departments and the Institute of Marine sciences (IMS). The Institute of Marine Sciences is located in Zanzibar at the same research station as the former East African Marine Fisheries Organisation. Recently, the Frontier project in the southern part of Tanzania and the Tanga Coastal Management Project have also played an active role in marine fisheries research.

A comprehensive review of the fisheries literature in Tanzania identified 334 references. Almost half of this research has been conducted in the last decade showing a recent increase in scientific capacity in fisheries research. The vast majority of recent work is difficult to obtain project documents, manuscripts, graduate student theses, and conference proceedings.

The state of existing scientific knowledge on marine fisheries in Tanzania is quite high. However, the geographic coverage has been rather low. There is also a need to expand the scope of research and improve the existing fisheries statistics.

Aside from studies that review and present general information on fisheries, the largest focus of fisheries research is baseline analysis. Baseline studies provide information on the status of fisheries in terms of catch, gear and type of vessel used, fishermen involved, species composition, and prices. This information is necessary for the formulation of fishery management options.

Almost all studies have been conducted in the vicinity of the research stations and at sites specified for donor-funded projects. Over 90 percent of place-based fisheries studies come from Zanzibar, Mafia, Mtwara, Tanga, Dar es Salaam and Songo-songo. Many areas have not been studied. For example, only a few studies could be identified for Rufiji, Pemba and Ruvu. Another scientific gap is the scope of research. Scientific research has been concentrated on major fisheries and as a result only about five fish species have been studied thoroughly.

### **3.5 Research recommendations to address gaps in scientific information in marine fisheries**

Most studies in the last decade are short term. Ideally, these need to be repeated and long-term studies supported so that reliable information on trends in the condition of the fishery can be made available to resource managers. The only long-term studies that are still are fish monitoring studies in Matemwe and Mkokotoni. Protocols for uniform and improved statistics collection techniques in landing sites over the whole country are needed to enhance comparability and credibility of information.

Research is needed on some of the minor fisheries such as octopus, sea cucumber, and the fence trap fishery. As the abundance and catch of major fish species continues to decline, the less well known fisheries become relatively more important. A greater research focus is also required on the biology of important commercial fish species (such as information on size at maturity). This knowledge is important to guide regulations and management strategies. Biological and basic science studies such as looking at feeding habits of fish can be used in ecosystem modelling and help predict best management options.

#### **Recommendations to fill the marine fisheries scientific gaps in a realistic period of time:**

- Standardised data collection methods and improve on the information dissemination mechanisms.
- Establish long-term studies.
- Broaden the geographic coverage.
- Expand the scope of research to include biological studies and minor fisheries.

### **3.6 Likely fisheries management solutions emerging from the scientific literature**

There is a need to introduce the size limitations on the harvest of marine products (such as sea cucumbers). There should also be promotion of good practices, such as returning small shells to where they were collected to enable them to grow out. The communities and relevant authorities



should carry out monitoring and surveillance in order to increase compliance with existing laws and regulations governing fisheries, such as localised harvest restrictions and seasonal closures and gear restrictions.

Public education and awareness campaigns should be conducted for raising and improving the general public's knowledge of fishery laws. The national policy for the protection, conservation and restoration of marine and coastal habitats should be improved.

In order to increase the information exchange and reduce duplication of research efforts, there should be an effective communication links between relevant research institutions within the country.

**Recommended marine fisheries management solutions:**

- Introduce size limitations on the harvest of marine products such as sea cucumbers.
- Improve the enforcement of the existing fishery laws.
- Improved national policy for the protection, conservation and restoration of marine and coastal habitats.
- Establish marine reserves and protected areas.
- Conduct public education and awareness campaigns
- Encourage community involvement in monitoring and control of the resource.
- Enhance the co-ordination and communication links between research institutions.

Community-based marine reserves and protected areas should be established in order to conserve and restore marine diversity and fish populations. These programs should generate income from responsible tourism and build awareness of the need for conservation. The community should be involved in monitoring and control of their resources.

## **4.0 Coral Reefs**

### **4.1 Importance of coral reefs in Tanzania**

The importance of coral reefs stems from their ecological importance. Reefs support an abundance of fin-fish, lobsters, prawn, crabs, octopuses, shellfish, and sea cucumbers, all of which are important in artisanal and commercial fisheries. Coral reefs support 70% of artisanal fish production in Tanzania. For coastal dwellers, fisheries are very important both as a source of food, supplying 90% of the animal protein they consume, and as a source of income, fishing often being their primary occupation.

On the other hand, 20% of the tourists who visit Zanzibar are specifically attracted by its diving suitability. During their visits, 68% dive at least once and 85% prefers snorkelling. Since almost all diving and snorkelling is done around coral reefs, this makes reefs a very important tourist attraction that brings foreign currency into the country and provides a livelihood for coastal people.

Coral reefs have a significant ecological importance for coastal ecosystems. Reefs support a great variety of microhabitats that result in a high diversity of plant and animal life, all of which are important in artisanal and commercial fisheries. Coral reefs also serve as breeding, nursery and feeding grounds for many marine animals.

Coral reefs are located along about two thirds (600 km) of Tanzania's continental shelf. Fringing and patch reefs predominate, but they are restricted to a narrow strip along the coast since Tanzania's continental shelf is not very wide. The islands of Unguja, Pemba and Mafia, as well as numerous small islands all along the coast, are for the most part surrounded by fringing reefs. Coral reefs have a number of ecological and economic values. Ecologically, they are important because of their great variety of microhabitats, which results in a high diversity of plant and animal life. Their productivity is particularly high because of high retention of nutrients with efficient biological recycling. Coral reefs serve as breeding, nursery and feeding grounds for many marine animals.

## **4.2 Status and trends in the condition of Coral Reefs**

Various surveys throughout Tanzania indicated a widespread degradation of coral reef environments. Since dynamite fishing has a widespread use in Tanzania, virtually all coral reefs along the coastal areas are badly degraded above a water depth of 10 m. However, below that water level, the reefs are reported to be prolific with coral growth and abundant with fish. Shallow reefs are almost completely destroyed.

The status of coral reefs in Tanzania is classified as fair. There is prolific coral growth below 10-m water level in many areas where corals tend to thrive. However, the available scientific information indicates a widespread degradation of coral reef environments. This is largely attributed to dynamite fishing which regardless of many awareness campaigns, seems to continue to be practised in many coastal areas.

## **4.3 Sources of pressure on Coral Reefs**

The greatest source of stress on coral reefs is related to destructive or bad fishing practices. By far the most destructive type of fishing is dynamiting. This has been practised in Tanzania for over 40 years now. Each blast of dynamite instantly kills all fish and most other living organisms within a 15-20 m radius and completely destroys the reef habitat itself within a radius of several meters. Besides these direct impacts, there are indirect impacts due to turbidity and sedimentation, which adversely affect marine life in a much wider area. With numerous blasts occurring daily on reefs all over the country, over a period of many years, the overall effect of dynamite fishing on coral reefs in Tanzania has been devastating.

The main sources of pressure on coral reefs in Tanzania includes; destructive fishing practices and associated coral reef degradation, coastal population growth and increased demand for coral reef products, pollution due to industrial and domestic discharge, natural causes e.g. storms and coral bleaching events.

Damaged reefs can take many decades to recover and some, in fact, may never recover. Dynamite fishing in Kilwa/Songo Songo area is usually conducted by fishermen from Dar es Salaam. On the other hand, in Lindi and Mtwara areas, dynamite fishing is done by local fishermen, usually youth. There are a number of factors that have led to continual use of dynamite fishing in Tanzania. These factors include poverty, increased human population, greed, lack of awareness, breakdown of traditional conservation practices, lack of law enforcement, inadequate legislation and lack of control of dynamite supplies.

Besides dynamite fishing, the use of seine nets around coral reefs is destructive in three ways. Firstly, fishermen often hit the coral heads in order to scare the fish out of hiding; secondly, the net becomes entangled with the corals, breaking them; and thirdly, the small-mesh size of seine nets results in the capture of many juveniles. Catching of juvenile fish results in the depletion of fish stocks, alteration in species composition, loss of species diversity, disruption of food webs, and disturbance of the natural equilibrium of reef ecosystems. In addition, there are several other fishing methods that may be destructive to the reef. These include octopus fishing, collection of shellfish, and the use of basket traps. Other harmful activities related to fishing include the dropping of anchors and boat grounding.

There are other human-caused impacts on coral reefs. Man causes many types of pollution due to industrial, institutional, and domestic discharge. Other pollution sources include, agro-chemical pollutants, sedimentation brought about by deforestation, poor agricultural practices and construction activities. All these pollutants can be detrimental to the health of corals when carried by seawater to the reefs. Other destructive practices include coral mining and uncontrolled tourism activities. The consequences of human-caused degradation of reefs is marked decrease in the diversity and abundance of fish, habitat loss, reduction in breeding and feeding grounds for fish and other organisms, and decline in the aesthetic value of reefs which reduces their attractiveness to tourists. The end result is a decline in income to coastal communities and to the country as a whole.

Natural impacts on coral reefs include storms, crown-of-thorns starfish and coral bleaching. The March-May 1998 coral bleaching in Tanzania was in part caused by higher than normal seawater temperatures and increased rainfall (lower salinity). The event was reported on all parts of the Tanzanian coast with variable severity. Bleaching was worse in shallow waters (reef flats) than in deeper waters. In Zanzibar, more than 60% of the scleractinian corals showed signs of bleaching, while a few corals were seemingly unaffected. On the economic side, some dive operators reported a decline in tourist potential due to the bleaching event.

#### 4.4 The state of existing scientific knowledge in coral reefs

Most of the scientific studies that have been conducted on coral reefs in Tanzania are either baseline or review studies. These studies give information on the importance, utilisation, threats, and degradation of coral reefs. There have also been reports on assessment of the extent of damage on reefs in particular areas, socio-economic impacts caused by coral bleaching events and the subsequent recovery of reefs. Many others have discussed management issues related to coral reefs. Only a few works are based on experimental or applied studies.

The state of existing scientific knowledge on coral reefs in Tanzania is quite high. However, the geographic coverage has been rather low. There is also a need to expand the scope of research and improve the communication and dissemination of scientific findings.

A few baseline studies on the structure and coral species composition of Tanzanian coral reefs were conducted about 30 years ago. Thereafter, there was a lull in such studies until recently (1990's) when extensive baseline studies were conducted by Frontier-Tanzania in Mafia. These studies have provided substantial amounts of information on biological and resource use aspects of coral reefs. In Tanga, recent baseline studies have been conducted under the Tanga Coastal Zone Conservation and Development Programme. Observation studies on the condition and health and biological status of coral reefs (hard coral cover, live coral versus dead coral, etc.), other than baseline studies, are rare. Repetitions of baseline studies as a way of monitoring changes in reefs have almost never been done. The applied and experimental studies that have been conducted in Tanzania are related to the recruitment of corals, coral larval settlement and transplantation of corals. These recent studies are a direct effort by researchers and graduate students at the University of Dar es Salaam (Institute of Marine Sciences and Department of Zoology).

Most studies on coral reefs have been carried out by capable to very capable scientists. Most junior students/scientists do not have the opportunity to learn SCUBA, snorkelling or marine survey techniques that are required to conduct research on coral reefs. Therefore, well-trained students and senior scientist who are capable of good quality output have conducted most of the work above.

#### 4.5 Research recommendations to address gaps in scientific information on coral reefs

Although the geographical coverage of coral reef studies has been quite good in Tanzania, there are many reefs that have not yet been studied or for which there is little information. Generally it is difficult to compare studies done in different places by different scientists since different methods or variations of methods are often used. Therefore there is also a need to standardise the methodologies. Since there are few experts in the country who are good at identifying all corals to species level, many studies do not fully identify all corals. There is therefore a need for Tanzania to recruit more researchers in this field.

**Practical recommendations for filling the coral reefs science gaps on in a realistic time period:**

- Standardised data collection methods.
- Establish long-term studies.
- Broaden the geographic coverage.
- Expand the scope of research to include biological and experimental studies

Most of the studies that have been conducted are of very short duration and some are a one-time study that limits our understanding of complex ecosystems such as coral reefs. Usually the short duration is due to lack of funds for longer periods of research. There is therefore a need to solicit more funds to support longer time research programs in Tanzania.

The literature reveals that very few studies were conducted in the 1980's, then there was a surge of studies in recent years. In between there was a long gap about which little is known about coral reefs in Tanzania. Unfortunately, this was a period when a great loss of coral reef habitat occurred and, likely, a reduction in coral diversity. It is therefore a challenge for scientists to find out how such important gap can possibly be filled.

Accessibility of literature on coral reefs to all scientists in Tanzania is still a big problem. Most of the available documents are those conducted by the University of Dar es Salaam. Reports of many studies done under specific research programmes are usually kept in private files, with no organised system for making them available to any other institutions and scientists working in this field. There is therefore a need for co-ordination of various groups conducting coral reef research in Tanzania.

#### **4.6 Likely coral reef management solutions emerging from the scientific literature**

Control of various types of pollution, the elimination of destructive and excessive fishing practices, proper management of tourism, and the elimination of coral mining are some of the measures which must be taken for the protection and conservation of coral reefs. For severely degraded reefs, mere protection is insufficient. Deliberate human intervention is required in order to accelerate and ensure the recovery of coral reef ecosystems. The removal of sediments and rubble is one simple method of intervention. Another method is the transplantation of coral fragments, whereby, fragments are broken from healthy colonies and attached to a suitable substrate using cement or glue. Moreover, artificial substrates or reef structures can serve as fish sheltering devices and can also enhance coral larval settlement. Such methods can potentially greatly improve the recovery of degraded coral reef ecosystems.

In areas that are moderately exposed to water movement, the transplantation of staghorn coral fragments at low density by tying them with string can be an effective, low tech method of rehabilitating damaged areas of reefs. Besides increasing cover of the transplanted species, this technique also enhances the habitat, making it suitable for the establishment of other hard corals, soft corals and other organisms.

**Recommended coral reefs management solutions:**

- Encourage the restoration efforts.
- Enhance the public education and awareness building.
- Community involvement in monitoring.
- Pollution control.
- Coral mining control.
- Eliminate the destructive and excessive fishing practices.
- Proper management of tourism

Training fishermen to transplant coral fragments using cement could be an effective way of restoring dynamited areas of coral reefs. It is also recommended that restoration work should be combined with ecotourism, whereby members of the communities receive payment from tourists for guided tours to coral reef and mangrove ecosystems while they carry on the restoration activities. It is also recommended that future projects/programmes in the region should combine involvement of local communities in the application of already developed restoration techniques.

An effective strategy should be developed to confront the problem of dynamite fishing. This should encompass a wide range of actions, such as continuous patrolling, police enforcement, improved legislation, increased fines, confiscation of vessels, jail sentences and making alternative fishing gear available at low cost. Moreover, in the long term, the local communities themselves must be educated and empowered to combat and stop dynamite fishing.

## **5.0 Mangroves**

### **5.1 Importance of mangroves in Tanzania**

Since early in the history of mankind, mangrove ecosystems and their surrounding habitats have played an important role in social and economic development of many coastal inhabitants all over the tropical world. Today, this unique but fragile ecosystem is still the main provider of various useful products such as firewood, charcoal, pole, tannin and traditional medicine. Many coastal communities in Tanzania depend on mangroves for income and employment. Mangroves also assume the function of feeding and nursery ground for many species of fish, shellfish, prawn, and crabs. In this case mangroves becomes important for the health of coastal ecosystem that indirectly provide food security for the coastal population and support the booming tourism industry in these areas. Mangroves also play a role in the protection of the shoreline, corals, seagrasses and algal beds against the wave and current forces. They also act as filters for terrigenous debris and suspended particulate matter.

Mangroves are an important source of renewable resource for coastal populations and are noted for their ecological and productive roles. They assume the role of feeding and nursery ground for many species of fish, therefore important for the health of coastal ecosystem. Mangroves also play a role in the protection of the shoreline, corals, seagrasses and algal beds against the wave and current forces.

Mangroves are salt tolerant forest ecosystems occurring in the tropical and subtropical coastlines and sheltered depositional bays of the world. Mangroves occur along most of the Tanzania coastline from Tanga in the North to Mtwara in the South covering an area of more than 116,000 hectares. They occur on most gently sloping low energy shores, on deltas, river estuaries, creeks and bays. The major river estuaries namely, Pangani, Wami, Ruvu, Rufiji, Matandu, Mbwemkuru and Ruvuma are home for extensive mangrove vegetation. Mangrove swamps are also well represented on the coasts of the main islands of Unguja, Pemba and Mafia.

## **5.2 Status and trends in the condition of mangroves**

After many years of continued use of mangrove products, over-exploitation has nearly occurred in some Tanzania coastal areas where the demand for mangroves has been high. Areas particularly affected are those near urban centres such as Maruhubi in Zanzibar and Kunduchi in Dar-es-salaam. Luckily, mangrove ecosystems are quite resilient, given sufficient time they can recover, especially in areas where the damage occurred due to mangroves cutting. However, the damage that is caused by oil pollution may be difficult for mangroves to regenerate. In this situation the only solution is through mangrove planting. The characteristic of many mangrove species of producing seedlings (vivipary) makes it easy for man to assist in mangrove reforestation by planting.

The condition of mangrove resource in Tanzania is classified as fair. However, over-exploitation has nearly occurred in some areas. The existing scientific data support this perceptions of resource depletion. Given the current rate of population growth, mangroves will be in even greater danger in the future.

## **5.3 Sources of pressure on mangrove resources**

Human population in Tanzania coastal areas has increased at a very fast rate in the past few decades. As a result, large mangrove forests have been cleared and converted to major ports, towns, settlements, salt pans, industrial sites as well as agricultural lands. Little consideration was given to the possible adverse effects of such development activities in mangrove habitat. Apparently, in the past, this rather unfortunate situation occurred partly because of lack of scientific information and guidelines for the decision-makers, and on the other hand because of ignorance of the local communities on the importance of this resource. Today there is more awareness about mangrove resources among resource manager and local communities. Extensive clearance of mangrove vegetation is therefore minimal.

Apart from clearance of mangrove forests to give way for development activities, mangroves are directly harvested for wood products e.g., firewood, charcoal making and building poles. This practice is still rampant at locations near urban centres and creates tremendous pressure on the resource. Human activities such as salt production and charcoal production have been pointed out as having the greatest negative impact on the resource.

The main sources of pressure on mangroves in Tanzania includes; clearance of coastal areas to give way to development activities due to increased coastal population growth, demand of mangrove products for firewood, charcoal making, building poles and fuel for lime-making.

#### **5.4 The state of existing scientific knowledge in mangroves**

There have been a number of studies on mangrove vegetation in Tanzania. The first dates back to 1929, when probably the first description of the vegetation, within the broader context of the mangroves of East Africa was given. An account of mangroves of Tanzania coastal areas was given in the 1970's. Most of the literature between 1930-1970 was based on surveys and descriptions based on visual observations. Such studies for instance gave information on Mangrove zonation, vegetation structure in terms of plant sizes and qualitative descriptions of regeneration and exploitation. None of the studies was detailed enough to give a comprehensive picture of the vegetation in Tanzania. Later, starting 1970's, more thorough investigations began to be conducted, including experimental and applied research on mangrove ecosystem.

The state of existing scientific knowledge on mangroves in Tanzania is quite high. However, due to limited research funding and lack of sophisticated satellite imaging techniques, the geographic coverage has been rather low. There is also a need to expand the scope of research and improve the communication and dissemination of scientific findings.

Although large-scale surveys have been conducted, especially along the coast of Tanzania mainland and Unguja Island, there are a number of sites that very little is known about their mangrove resources. For example, the mangroves on Pemba and Mafia Islands have not been adequately studied. The geographic coverage for mangrove research needs to be increased. The information available on mangroves in Tanzania is quite reliable. The studies were conducted by researchers with good knowledge of mangrove ecosystem. Most were scholars with a rich background of basic botanical knowledge and experience or else were student in pursuit of academic honours. Therefore the quality of the available information is considered to be high. However, the scientific information on the mangrove resource is not readily accessible. The reports are scattered in many places, sometimes in the individual files of researchers. Even published Journals can sometimes be difficult to obtain in Tanzania. The availability of information on mangroves in Tanzania is therefore considered to be low.

#### **5.5 Research recommendations to address gaps in scientific information on mangroves**

Since some areas have not received enough attention, there is need to conduct more studies and update the list of mangrove species available in Tanzania. The subject coverage of mangrove research can be expanded. An ecosystem approach to the study of the mangrove resource should be adopted. This would give the information needed to understand the complex role of mangrove



ecosystem. The inter-linkage between mangrove ecosystem and other coastal ecosystems should especially be encouraged. Such information is very useful in designing strategies for proper management of coastal resource.

There have been very few studies conducted between 1930-1960, the available information during this period is very preliminary and observational in nature. More thorough investigations began to be conducted in the 1970's. However, these investigations were mostly short-term studies. There is therefore a need for longer-term studies to be launched. This may lead to new discoveries in terms of seasonal behaviour and long-term trends of the resource.

**Practical recommendations for filling the mangroves science gaps in a realistic time period:**

- Broaden the geographic coverage.
- Establish long-term studies programs.
- Standardised data collection methods.
- Improve the link between local researchers and their institutions.
- Expanded scope of research to include inter-linkage between mangrove ecosystem and other coastal ecosystems.

In order to increase the availability of mangrove information in Tanzania, there is a need to establish a link and encourage sharing of information between mangrove researcher and relevant concerned institutions. Annual symposiums and voluntary deposition of reports in major libraries specialised in marine sciences in Tanzania is recommended. There is need to standardise methodologies so that results from various studies can be compared. This is an issue in those mangrove studies where information is gathered by visual or observational methods, which may differ, between researchers.

## **5.6 Likely mangroves management solutions emerging from the scientific literature**

Most recommendations are aimed at one objective, “sustainable management of the resource”. The strategy advocated is the involvement of local people who are in contact with the resource every day. The community should be educated on the ecological importance of the resource and how it is connected to the other marine resources. This is an essential steps towards the achievement of effective community based resource management.

It is recommended that restoration programmes (including planting) should be carried out in order to regenerate areas that have been seriously affected. There is also a need to provide alternative sources for firewood and building poles. This will help to take off the pressure on mangrove resource. The establishment of *Casuarina* forests as an alternative has often been suggested. Any future planning or implementation of development project in areas where there are mangrove habitats should first seek scientific advice from relevant authorities and put due consideration on the long-term sustainable yield of the resource.

**Recommended mangroves management solutions:**

- Improved national policy for the protection, conservation and restoration of mangrove forests.
- Harvest size limitations.
- Community based resource management.
- Public education and awareness on ecological importance of the resource.
- Mangrove planting.
- Enhanced co-ordination and communication links between research institutions.
- Establishment of *Casuarina* forests for alternative use of mangroves.
- Development plans in mangrove areas should seek scientific review.

## 6.0 Other Marine Living Resources

### 6.1 Importance of other marine living resources in Tanzania

The other marine living resources available in Tanzania coastal waters includes; seaweeds, seagrasses, benthic fauna, sea turtles, marine mammals, zooplankton, phytoplankton, and marine birds. These living resources play a major role in the wellbeing of the coastal ecosystems and supporting the local people's lives as they are a major source of food and cash.

Seaweeds are large macroscopic non-vascular plants, known as the Algae. The genus *Eucheuma*, occurring on the shorelines of Tanzania is the most favoured seaweeds. Their current industrial uses include cosmetics, food derivatives, use as health foods and medicinal uses. *Eucheuma* species have been harvested for export trade for over four decades due to their rich content of the phycocolloid, carrageenan. Because the supply from the wild stocks of *Eucheuma* could not meet the demand for the product, research was directed towards the culture technology in the past few years. Currently, seaweed farming is increasingly becoming an important economic activity in many coastal communities of the United Republic of Tanzania.

Seaweeds, seagrasses, benthic fauna, sea turtles, marine mammals, zooplankton, phytoplankton, and marine birds are just part of the other marine living resources available in Tanzania coastal waters. They play a major role in the sustainability of coastal ecosystems and the livelihood of many coastal communities as a source of food and cash.

There are about 12 species of seagrasses in Tanzanian coastal waters. Their importance lies in their interactions with other ecosystems in the marine environment, especially mangroves and coral reefs. They form dense beds that cover large areas of coastal waters and perform a wide range of biological and physical functions. Their most notable role is to provide breeding, nursery and feeding grounds for many invertebrates and vertebrate species. Moreover they provide shelter and refuge for resident and transient adult animals. As a result both artisanal and commercial fishery activities are carried out in these areas. Seagrass beds also support complex trophic webs both through dead and living biomass.

Phytoplankton and zooplankton collectively constitute the plankton which are very important in the food chain and hence ocean productivity. Many benthic and pelagic fish and invertebrates feed on plankton. Phytoplankton forms the first trophic level as primary producers and so they are able to sustain the productivity of the higher trophic levels. Zooplankton are consumers of the phytoplankton, forming the next step in the food chain as secondary producers. Blooms of phytoplankton occur in tropical coastal waters, some resulting in higher productivity while others lead to contamination of shellfish or massive fish kills.

Benthic fauna commonly found in Tanzania include molluscs, crustaceans and sea cucumbers. At present there is no monitoring or control of the commercial harvesting of the majority of these invertebrate resources. This, coupled with lack of information on the stock abundance, put the resources at very serious danger of depletion. For example, available data suggest that stocks of sea cucumbers have been drastically decreasing, as a result of intensive over-exploitation. The extensive collecting of gastropods for the ornamental shell trade has had the same effect in that it has caused this resource to decline. Tanzania has a variety of habitats along the coast, which are attractive to seabirds in terms of feeding and nesting sites. The associated areas of open water such as the Zanzibar and Mafia channels and the Indian Ocean itself provide rich feeding grounds for these seabirds. The types of waterbirds that are considered here are “those which spend much of their time above, near or in coastal marine waters.” Direct exploitation of seabirds for food along the Tanzania coastline is negligible. However, they are very important in nutrient cycling, for example; guano produced by waterbirds has been shown to be critical in maintaining forests on the coral rag.

Two main types of marine mammals frequent our coastal waters; the toothed whales including the dolphins and porpoises, and the baleen whales. These mammals spend the boreal summer feeding in the polar regions and the winter in warmer tropical waters which provide a suitable range of temperature for giving birth and suckling their young. Some of the smaller species may occasionally be killed in fishing nets, but the impact on the stocks is minimal. The dugong is another type of marine mammal that is found in Tanzanian coastal waters. There are two locations where dugong populations are found in Tanzania: Pemba–Zanzibar channels and the Rufiji–Mafia areas. Dugongs feed on seagrasses and can consume up to 30 kg daily. The dugong is killed for its flesh and its oil, and local populations in Tanzania have been nearly decimated. Further threats to dugong populations include habitat degradation that might affect their food supply and dynamite fishing.

There are five species of marine turtles in the Tanzania coastal waters. Sea turtles are adapted to a life in the sea and come out on land only for nesting. The nesting period is the easiest time for predators to catch turtles. This results in a direct reduction of reproduction since the females are killed before nesting. The eggs and hatchlings are equally susceptible to predators. Turtles are killed for their meat, eggs and the carapace (“tortoise shell”). Turtles are especially vulnerable to pollutants since many feed on invertebrates, which concentrate various pollutants. Meat from such turtles could cause serious public health problems.

Resource	Condition	Trend	Scientific data to support trend information
<b>Seaweeds</b>	Good	Some wild harvesting, but farming is source of major supply	Yes
<b>Seagrasses</b>	Good	No direct utilisation or extensive destruction known	No studies have been done
<b>Benthic fauna (molluscs, crustaceans, seacucumbers)</b>	All 3 overexploited	Exploitation goes unregulated and is increasing	Yes
<b>Sea turtles</b>	Endangered	Declining populations due to non-commercial exploitation	There is lack of recent population studies.
<b>Marine mammals (dugong, cetaceans)</b>	Dugongs endangered, Cetaceans unknown	Dugongs are nearly decimated. Cetaceans are not thought to be in significant danger, but no studies have been done.	Yes for dugongs, No for cetaceans
<b>Marine birds</b>	Unknown	Unknown	Unknown
<b>Planktonic organisms</b>	Unknown	Unknown	Unknown

*Measure of Condition: pristine/good/overexploited/endangered/unknown*

## 6.2 Status and trends in the marine living resources

Studies leading to determination of the status of the resource are rare. However, various statements that point to resource depletion as a result of uncontrolled exploitation have been given. For example; there has been a call for an urgent status assessment of marine mammals. The gastropods, which have commercial value because of the shell trade, are also considered over-exploited.

Dolphins, porpoises, and baleen whales are apparently not commercially exploited in Tanzania. However, the populations of both dugongs and marine turtles are exploited and these animals are regarded as endangered. It is also believed that sea cucumber stocks are declining especially along the Bagamoyo coast. The collectors are now reported to be using SCUBA diving, thus depleting the resource even further.

## 6.3 Basic causes of pressure on other marine living resources

The basic cause of pressure on these resources is due to uncontrolled uses leading to over-exploitation. There are various resource use types depending on the species in question. For example, Seaweeds of the genus *Eucheuma* are exploited for phycocolloid (carrageenans) production. Turtles are slaughtered for their meat, eggs and tortoise shells whenever they are caught, but they are not targeted. Fishermen in Mtwara were reported to kill dolphins for use as bait in the longline fishery, targeting tiger sharks *Galeocerdo cuvieri*. Dugongs are killed for their meat and oil. Sea cucumbers are harvested and prepared as beche-de-mer which is usually exported. Besides the foregoing consumptive uses, there are non-consumptive uses with some of

the resources. For example, mollusc shells are collected for the curio trade. A certain type of seaweed is also being harvested in Bagamoyo for use as bait for rabbitfish.

The main sources of pressure on the other marine living resources includes; uncontrolled resource use, destruction of habitats by human factors (oil spills, chemicals, sand mining deforestation and dynamite fishing), destruction of habitats by natural factors (storms and beach erosion) and coastal population growth and demand of the resources

There is information to support human impacts on these resources and their habitats. These are mainly anthropogenic factors due to pollution (oil spills, chemicals), sand mining and habitat destruction (deforestation and dynamite fishing) that put these resources in serious danger. Chemical pollutants such as petroleum products in the water are known to interfere with olfaction in marine turtles, which may be used in navigation and orientation. Turtles are especially vulnerable to pollutants because many feed on invertebrates, which concentrate various pollutants.

Other causes of pressure on the other living resources are due to natural factors. These include storms and beach erosion. The latter event can lead to reduction in size or complete disappearance of an island as has been the case with Maziwi Island. The extent of the impact that resulted from submergence of Maziwi Island on the populations of Green Turtle has not been determined.

## **6.4 The state of existing scientific knowledge**

There has been paucity of data for the period between 1950-1960. A number of studies were conducted in the 1970's, but the majority of the available information comes from the studies conducted in 1990s. The trend in these studies has been a gradual shift from baseline studies, which described the distribution, species diversity, life history and aspects of resource use and conservation between 1960-1980, to applied studies (mainly mariculture) in the 1990's. A good example is the emergent of seaweed farming research. Experimental studies are generally rare. This is partly attributable to inadequate research facilities to support the experiments.

The quality of existing scientific knowledge on other marine living resources is quite high. However, the geographic coverage is rather low. There is also a need to expand the scope of research and improve the communication and dissemination of scientific findings.

Although the majority of the studies made use of "low tech" methods, very useful information was gathered. The methods used for these studies are scientific and acceptable. The researchers involved are senior scientists of high calibre, and where postgraduate students were engaged close supervision was put in place. The quality of the scientific knowledge is therefore considered to be high. The majority of the studies have been published in international refereed journals, thus should be accessible or retrievable. The view on research quality given above is based on the studies that were published in these journals only. However, the fact of the matter is, the journals

are either not available locally or where available, some volumes for certain years could be missing all together. Accessibility of University theses and in-house reports is also difficult.

## **6.5 Research recommendations to address gaps in scientific information**

Our experience in basic marine biological research has so far been confined mainly to inshore and shallow water environments. Other important areas such as deep-sea ecology, offshore pelagic ecosystem etc. are still untouched. Most of the studies have been conducted around major urban centres e.g., Dar es Salaam, Zanzibar and Tanga, or in the vicinity of research institutions. There have been very few studies in remote places. There is therefore a need to increase the geographic coverage of the studies.

### **Practical recommendations for filling the other marine living resources science gaps in a realistic time period:**

- Broaden the geographic coverage.
- Establish long-term research programs.
- Improved fisheries data collection and fisheries statistics.
- Training of more marine scientists.
- Strengthen of research and monitoring programs.
- Expanded scope of research to include the role of sea cucumbers and molluscs in coastal ecosystems, the status of waterbirds and information about sea turtles, marine mammals, zooplankton and phytoplankton.

In order to improve our understanding of the coastal resources it is recommended that fisheries data collection should be improved and research and monitoring be strengthened. It is also recommended that interdisciplinary research that involves Government officials and local communities be practised. There is a need to conduct biological surveys to determine the status of waterbirds in Tanzanian coastal waters. There is currently very little information about this resource in the literature.

Very little is known of the role of sea cucumbers and molluscs in the coastal ecosystems. It is therefore recommended that more studies on the ecology and population dynamics of sea cucumbers and molluscs be conducted to fill this information gap. There is also a lack of detailed information about marine birds, sea turtles, marine mammals, zooplankton and phytoplankton in Tanzania waters. This is considered as a major bottleneck in resource management and conservation. There is paucity of data on resource abundance, distribution, trends of exploitation, biodiversity and biology of most species. It is therefore recommended that more research work should be carried to expand the scope of research in these subjects.

Research that targets at among other things, education of resource users on the importance of conservation of the other living resources should be conducted. These projects must ensure active participation of local communities in order to gain from indigenous knowledge and skills. It is crucial that the local knowledge should be documented as soon as possible in order to build a broader base in terms of future management. With the exception of doctoral studies, many studies were carried out over a relatively short period of time (single day to less than a year). It is therefore recommended that, subject to availability of funding, long-term studies should be

initiated. The need to train more marine scientists can not be over-emphasised. The limited geographical coverage in the studies reported here is partly attributable to shortage of scientists in various coastal regions of Tanzania. Short courses focusing on specific topics should be planned so as to introduce the scientists with modern research methodologies.

## 6.6 Likely marine living resource management solutions emerging from the scientific literature

In order to improve seaweed farming, it is recommended that *Eucheuma* plants be grown at medium densities. Extensive farms should be discouraged to avoid *Ice-Ice* disease (the stressed condition of *Eucheuma*). This recommendation is also aimed at reducing the negative environmental impact of *Eucheuma* on other marine flora and fauna. Any new scientific findings from the research institutions must be communicated to seaweed farmers and resource managers.

In order to conserve marine turtle it is recommended to immediately impose a ban on commercial trade of tortoise shells. Other recommendations include the introduction of awareness raising campaigns that marine turtles are endangered and must not be killed. Introduction of tighter enforcement of existing legislation and a ban on all exports of chelonian carapaces and scales. The inclusion of concentrated turtle breeding sites in national nature reserves or parks.

In order to conserve coastal waterbirds, effort should be made to reduce the disturbance or destruction of their habitats. Other recommendations include the establishment of nature reserves and public awareness campaigns on the importance of this resource, especially in coral rag areas.

### **Recommended other marine living resources management solutions:**

- Discourage extensive seaweed farms.
- Improved Communication link between research institutions and local communities.
- Ban on commercial trade of tortoise shells.
- Public education and awareness building on importance and the threat of the resources.
- Community involvement in monitoring and control.
- Reduce disturbance or destruction habitats.
- Harvest size limitations and improved enforcement of existing laws.

Since little is known of the role of sea cucumbers and molluscs in the ecosystem(s), it is recommended that the sales of shells and beche-de-mer should be reduced until sufficient information on their ecology and population dynamics are known.

There is also a need for creation of awareness at all levels of way the ecosystem function, its importance, threat and need for change of policies is necessary. Local communities should be made aware of the legislative process and opportunities for its use. Moreover, there is a need to provide translated educational materials, and films on the major habitats and resources.